



# pFlogger: The Parallel Fortran Logging Utility

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# POSITION

Use of text-base messages in HPC applications is typically undisciplined, leading to a chaotic hodgepodge that is of limited value to developers and users. Logging frameworks can bring order to the chaos and significantly improve our ability to extract useful information.

Typical problems:

- ❖ Important messages obscured by fountain of routine messages
- ❖ Performance
  - ❖ User adds a print statement in an inner loop or across all processes
- ❖ Anonymity – important message of unknown origin
  - ❖ Which process
  - ❖ Which software component
- ❖ Loss of productivity
  - ❖ Recompile to activate low-level debug diagnostics

## If only we could ...

- ❖ Route warnings and errors to prominent location
  - ❖ And profiler data and ...
- ❖ Suppress low severity ("debugging") messages
- ❖ Suppress duplicate messages on sibling processes
- ❖ Annotate messages with:
  - ❖ Time stamp
  - ❖ Process rank
  - ❖ Software component
  - ❖ Other application-specific metadata
  - ❖ ...

**And ... do all of this dynamically at run time (without recompilation)**

# The Python Logging Framework

The main classes:

- ❖ **LogRecord** – encapsulates a message and its context
  - ❖ Severity is determined statically (in source code)
- ❖ **Handler** – represents different *audiences* for messages
  - ❖ Generalization of a file: could be console, email, SMS, ...
  - ❖ Has a run-time severity level threshold
- ❖ **Logger** – represents different *creators* of messages
  - ❖ Typically one per software component/library
  - ❖ Each has a run-time severity threshold
  - ❖ Has a list of associated Handler objects
    - ❖ Also routes messages through ancestor Loggers' handlers.

## Severity Levels

10 DEBUG

20 INFO

30 WARNING

40 ERROR

50 CRITICAL

0 NOTSET\*

Other important classes:

- ❖ **LoggerManager** – container of Logger objects
- ❖ **Formatter** – used by Handler objects to annotate messages (uses dictionary)
- ❖ **Filter** – Selectively suppress messages in Loggers and Handlers

# Fortran Translation of Python Logger

Wanted something like this for a long time ...

Enabled by two technologies:

- ❖ Arrival of robust object-oriented capabilities in Fortran compilers
  - ❖ But still have several compiler-specific workarounds ...
- ❖ Internally developed FTL (poor-man analog of C++ STL)
  - ❖ Substantially reduces effort to define/use vectors and dictionaries from Fortran
  - ❖ In process of being released as open source (more on this later)

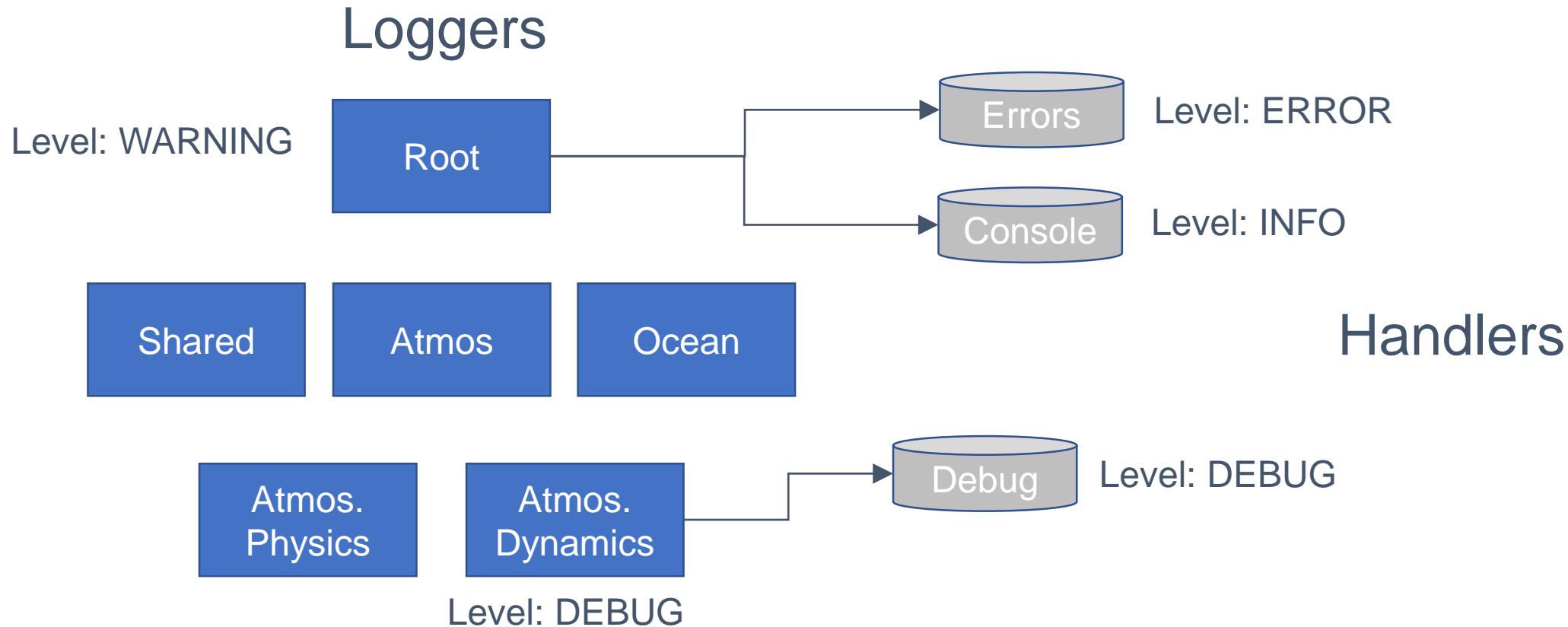
Alternative approach: Provide Fortran wrappers to Python logger.

# Configuring Logger (via YAML)

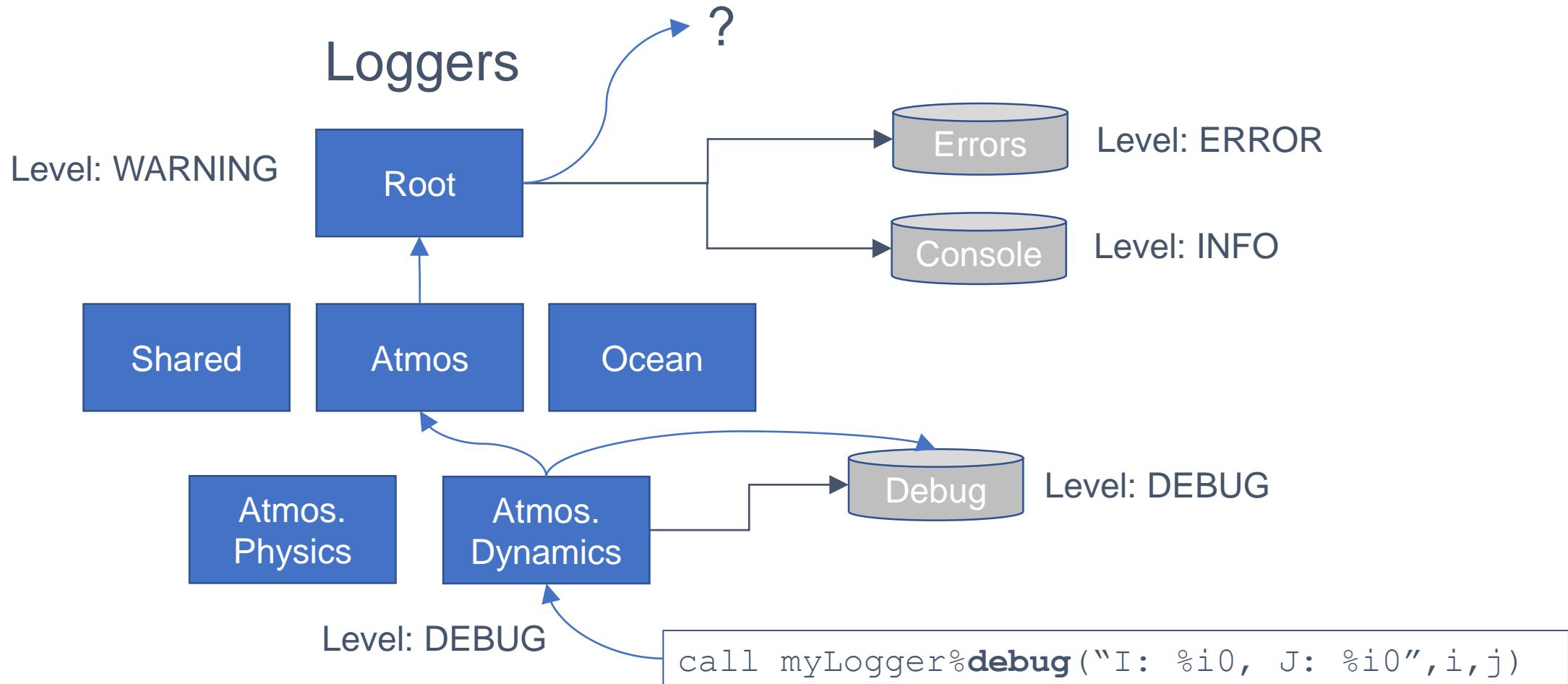
```
formatters:  
  basic:  
    class: Formatter  
    format: '%(name)s - %(levelname)s - %(message)s'  
  column:  
    class: Formatter  
    format: '(%(i)13.3,%(j)13.3): %(levelname)s'  
  
handlers:  
  console:  
    class: StreamHandler  
    formatter: basic  
    unit: OUTPUT_UNIT  
    level: WARNING  
  warnings:  
    class: FileHandler  
    filename: warnings.log  
    level: WARNING  
    formatter: basic
```

```
...  
  
root:  
  handlers: [console, warnings]  
  
loggers:  
  main:  
    level: INFO  
  main.A:  
    level: WARNING  
  main.B:  
    level: INFO
```

# Life of a Message



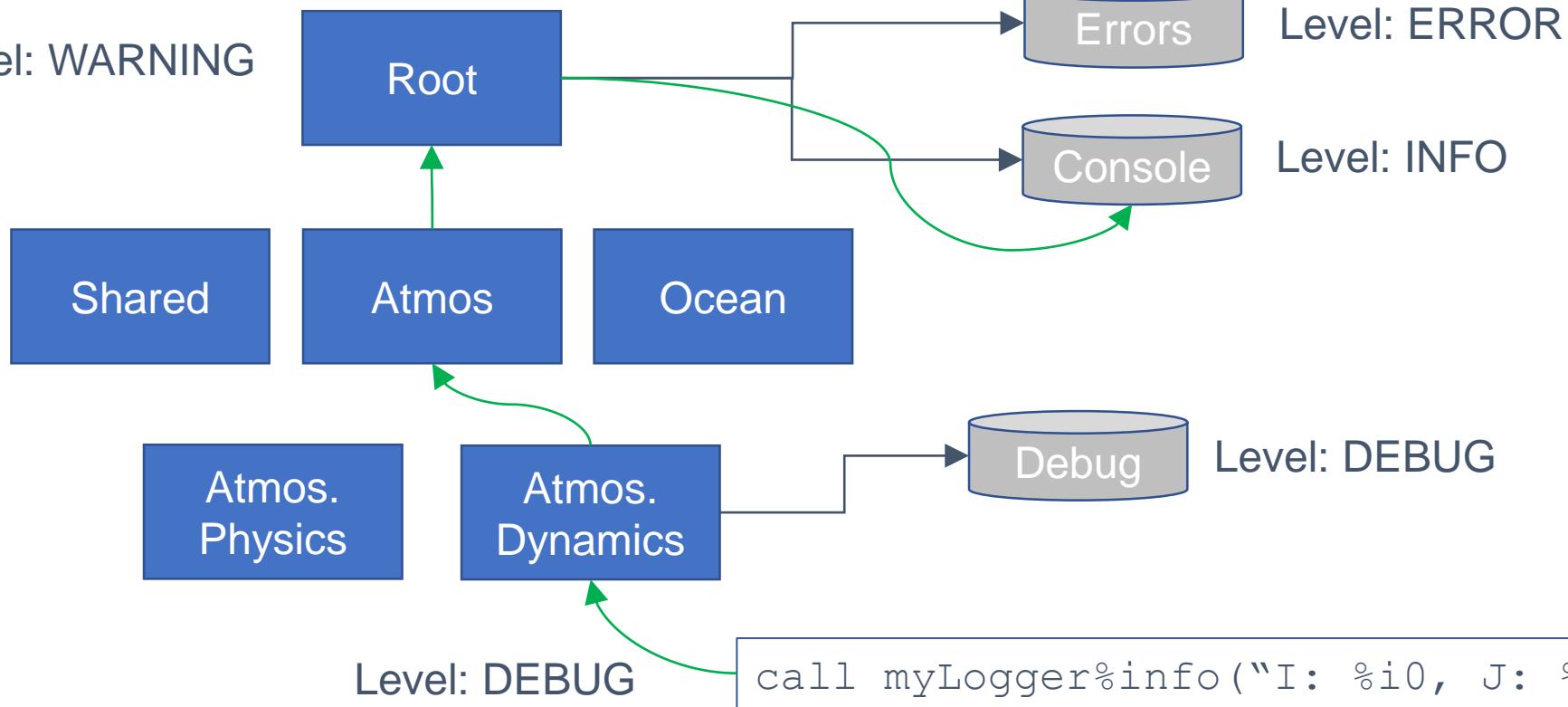
# Life of a Message



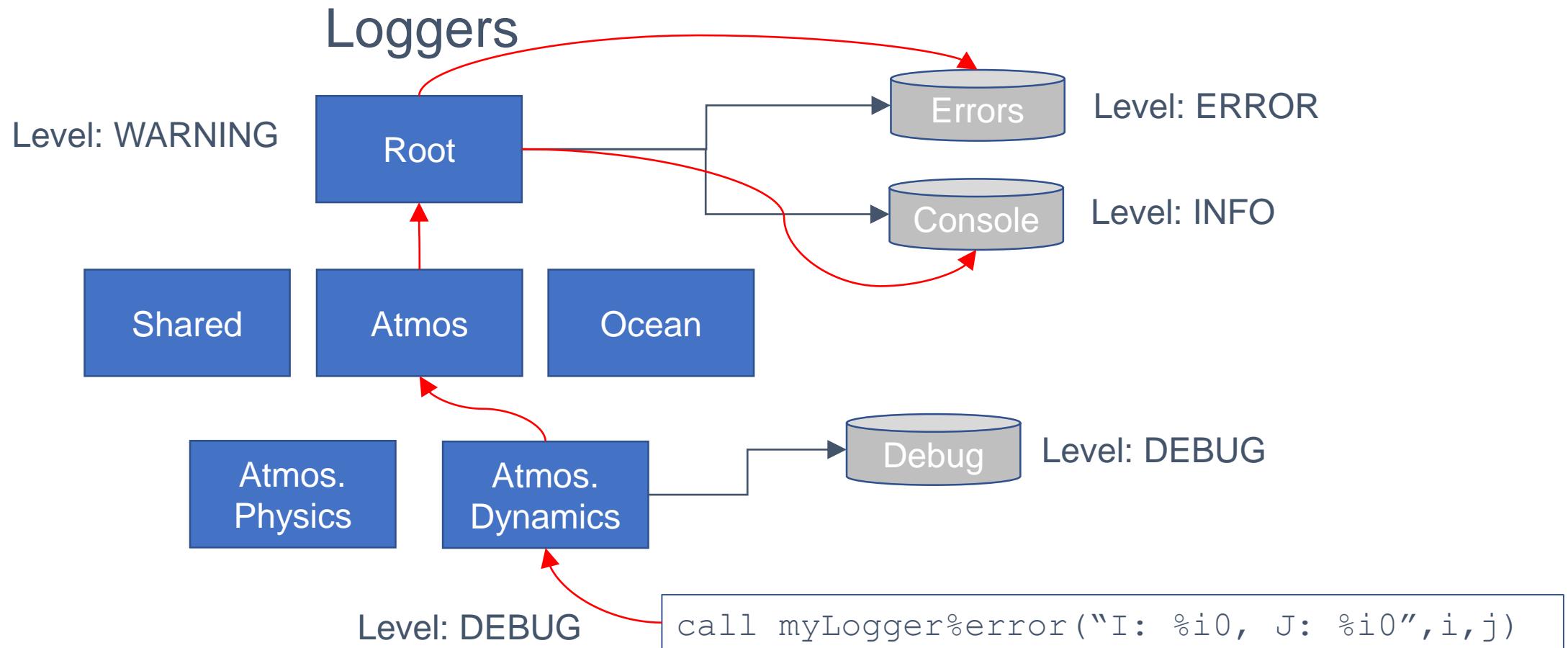
# Life of a Message

## Loggers

Level: WARNING



# Life of a Message



## Extensions for MPI Use

- ❖ LoggerManager – configured with global comm (defaults to MPI\_COMM\_WORLD)
- ❖ Logger – can be associated with a communicator (defaults to global)
  - root\_level: independent threshold for root process
- ❖ Handler
  - Lock – used to allow multiple processes to share access to a file
    - MpiLock – uses one-sided MPI communication
    - FileSystemLock – limited portability, but allows multi-executable sharing
  - MpiFilter – used to restrict which processes' messages are reported
  - MpiFileHandler subclass
    - Messages from each process are routed to separate file
- ❖ MpiFormatter subclass: knows about rank and #PE's for annotations

# Advanced Capabilities

I.e., Things that are harder to use ....

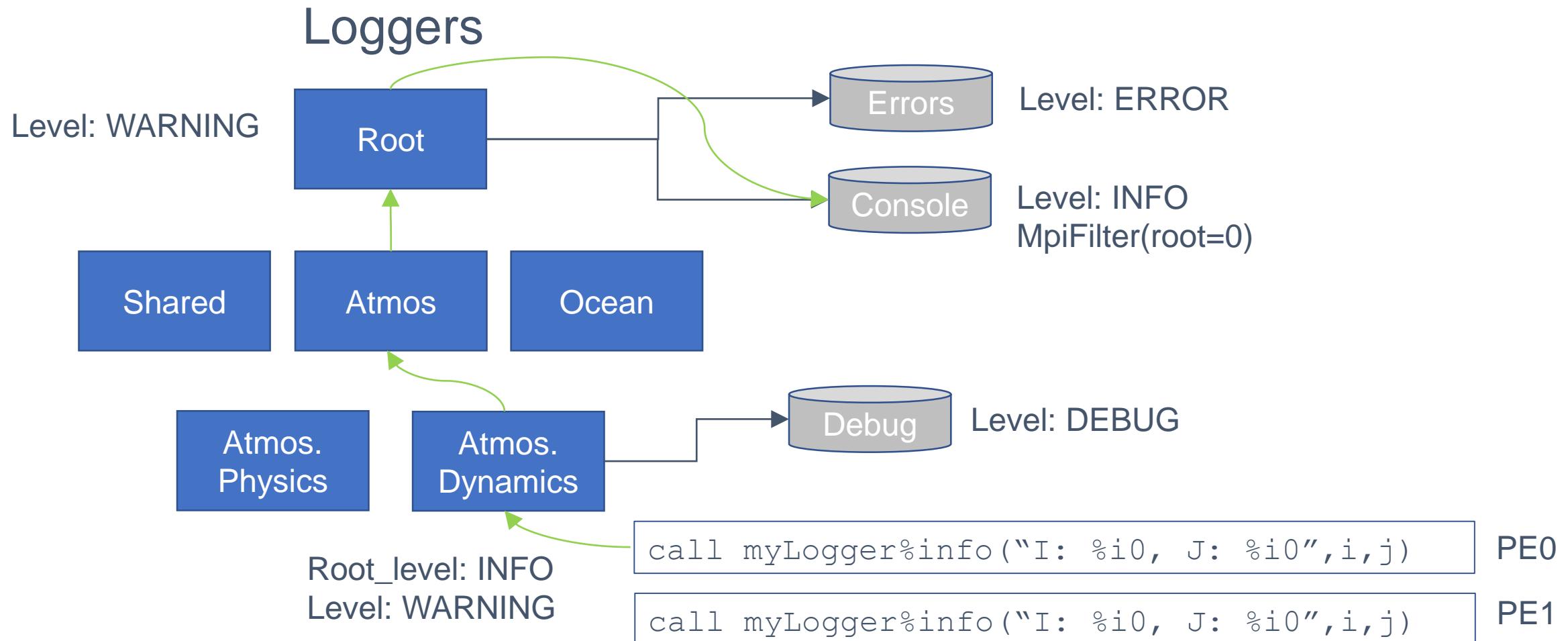
**Subcommunicators:** How to specify in run-time configuration file?

1. Construct communicators prior to initializing framework
2. Build dictionary of named communicators
3. Pass as optional argument to framework configuration step

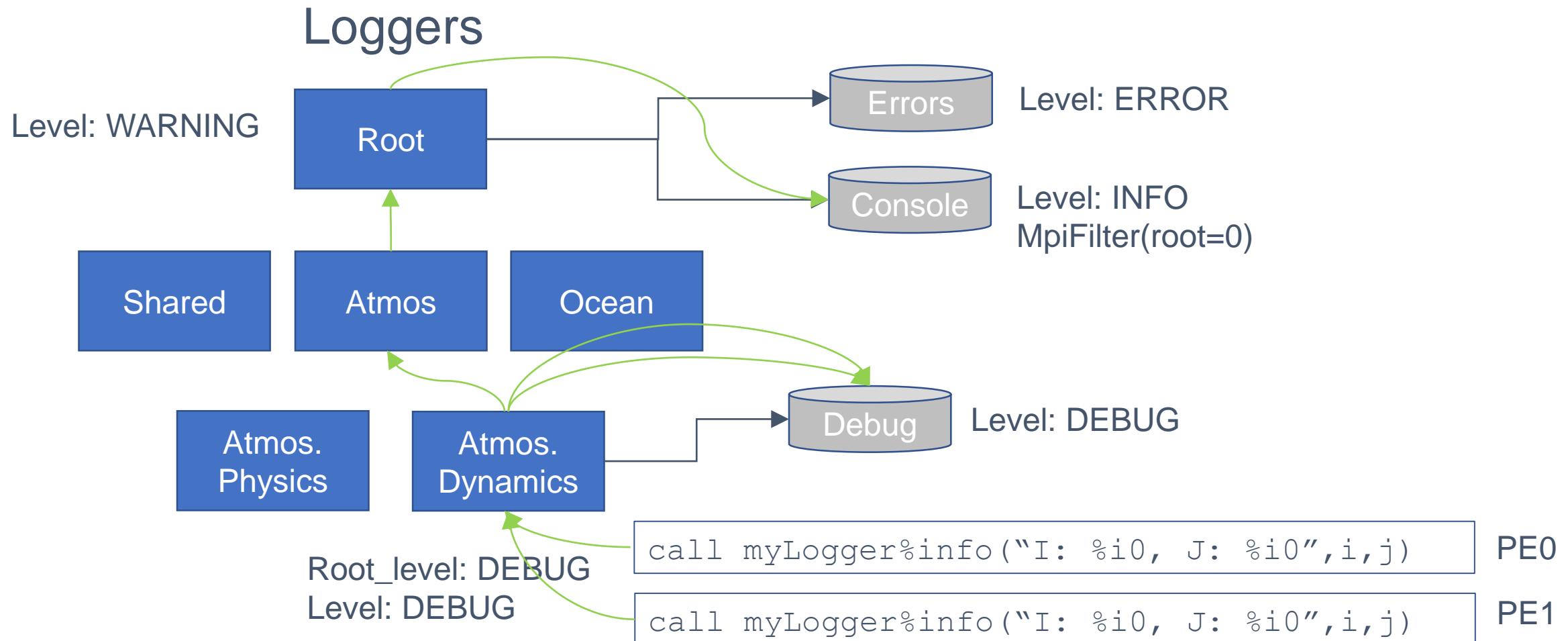
**Simulation time:** Enable annotation of messages with model's internal representation of time/phase information

1. Create a custom procedure that accesses model internal state and returns a dictionary of time-related fields. E.g. {'year':2000, 'month':'May', 'phase':'quality control'}
2. Set logger global procedure pointer "get\_sim\_time()" to custom procedure.

# Life of a Message: MPI



# Life of a Message: MPI



# Instrumenting with pFlogger

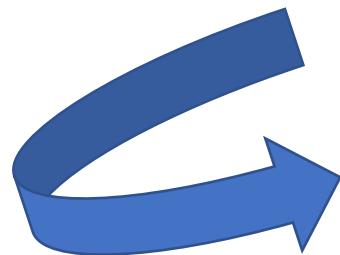
Easy and straightforward:

- ❖ Initialization – near beginning of application
- ❖ Declare logger in each component use `pl`
- ❖ Replace print/write statements use `File`

```
if (am_i_root()) write(*, *
```

```
ent use pFlogger
use ... pFlogger call initialize(MPI_COMM_WORLD)
... Call logging%load_file('my_config.yaml')
classLogger, pointer :: myLogger
...
myLogger => logging%get_logger('full.name')
```

```
call my Logger%info('mass: %*', m)
```



# Benchmarks

Synthetic use case performance ratios

Use Case	Intel-17	GCC 7.1	NAG 6.1
Simple text message	5.5x	10x	15x
Message with scalar items	8x	16x	5x
Suppressed message	0.004x	0.03x	0.15x
Split parallel log message	1.1x	7x	-
Shared parallel log message	5x	8x	-

Build times of GEOS GCM (Large Earth system model)

Compiler	Optimization	T baseline	T pflogger
Intel-17	O0	218.6	250.3
Intel-17	O3	735	797.
Gfortran-7	O0	178.3	198.3



# Open Source?

In progress, but the gears at NASA turn slowly ...

- ❖ Can arrange for project license for groups that have NASA or other US gov't affiliation.
- ❖ Will otherwise collect email addresses from interested parties for when open source is achieved.
- ❖ If interested, send me email [Tom.Clune@nasa.gov](mailto:Tom.Clune@nasa.gov)

## Summary

- ❖ pFlogger appears ready for beta testing in HPC applications
  - ❖ Further optimizations needed for intensive use cases
  - ❖ Some tweaks to initialization interfaces are expected
- ❖ Plan to integrate pFlogger into dev branch of GEOS in the near future
  - ❖ Full instrumentation will proceed on a longer time scale
- ❖ Largest problem – too much flexibility!



## Thanks to ...

NASA's Modeling and Prediction Program for funding this work.



## References

V. Sajip, “logging -- logging facility for Python”,  
<https://docs.python.org/2/library/logging.html>

## In defense of the PRINT statement ...

PRINT is very versatile:

- ❖ Arbitrary number *and* type of items
- ❖ Convenient default (\*) formatting
- ❖ Flexible edit descriptors that allow for precision formatting

But ... most of this versatility is frozen at compile time.

OTOH, very difficult to emulate the versatility in a procedure interface.